Tuning of Monte Carlo Event Generator PYTHIA 6 to Min Bias Data

(Preliminary Results)

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Motivation

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- Understand the whole event (not just the pQCD part)
- No MC generator can reproduce all MB observables at the same time
- To describe data the best possible way MC models need to be tuned

PYTHIA Model

- Multiparton Interaction Model
- Pt ordered parton shower

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- “In the full event generation process, probably no other area is as poorly understood as this one!” (PYTHIA manual)

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- The hard scatter cross section is extended to the low pt(diverges for pt $\rightarrow$ 0)
- A regularization parameter is introduced
- All interactions are simulated in decreasing order of pt

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- Fragmentation Parameters were tuned to e+e- data(ALEPH)

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- Multiparton Interaction model parameters are tuned to pp/pp- data

Fit Procedure

- Linear parameterisation is used, most efficient with the possibility of iteration, allows many (10-20) parameters to vary simultaneously

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- Central value and tuning interval for each parameter are chosen, and run the generator with these settings
- This prediction is fitted to data (minimal $\chi 2$)

List of observables

Analysis	Observable	Analysis	Observable
ATLAS 0.9TeV, $n_{ch} \geq 1$, p_t>0.5GeV, $\lvert\eta\rvert < 2.5$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{d\eta}$	CDF-II 1.96TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{dn_{ch}}$
ATLAS 0.9TeV, $n_{ch} \geq 1$, p_t>0.5GeV, $\lvert\eta\rvert < 2.5$	$\frac{1}{N_{ev}} \cdot \frac{1}{2\pi p_t} \cdot \frac{d^2 N_{ch}}{d\eta dp_t}$	CDF-II 1.96TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\frac{1}{N_{ev}} \cdot \frac{1}{2\pi p_t} \cdot \frac{d^2 N_{ch}}{dy dp_t}$
ATLAS 0.9TeV, $n_{ch} \geq 1$, p_t>0.5GeV, $\lvert\eta\rvert < 2.5$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{dn_{ch}}$	CDF-II 1.96TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\frac{1}{N_{ev}} \cdot \frac{1}{2\pi} \cdot \frac{d^2 N_{ch}}{d\eta dE_t}$
ATLAS 0.9TeV, $n_{ch} \geq 1$, p_t>0.5GeV, $\lvert\eta\rvert < 2.5$	$\langle p_t \rangle vs. n_{ch}$	CDF-II 1.96TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\langle p_t \rangle vs. n_{ch}$
CMS 7TeV, no p_t cut $\lvert\eta\rvert < 2.4$	$\frac{1}{N_{ev}} \cdot \frac{1}{2\pi p_t} \cdot \frac{d^2 N_{ch}}{d\eta dp_t}$	CDF-I 0.63TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{dn_{ch}}$
ALICE 7 TeV, no p_t cut, $n_{ch} \geq 1$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{dn_{ch}}$	CDF-I 1.8TeV, $n_{ch} \geq 1$, p_t>0.4GeV, $\lvert\eta\rvert \leq 1.0$	$\frac{1}{N_{ev}} \cdot \frac{dN_{ev}}{dn_{ch}}$

ALICE	0.9 TeV,	no p_t cut, $n_{ch} \geq 1$	$\left.\frac{dn_{ch}}{d\eta}\right\rvert_{\eta=0}$
ALICE	7 TeV,	no p_t cut, $n_{ch} \geq 1$	$\left.\frac{dn_{ch}}{d\eta}\right\rvert_{\eta=0}$
ATLAS	0.9 TeV,	p_t>0.5GeV, $n_{ch} \geq 6$	$\left.\frac{dn_{ch}}{d\eta}\right\rvert_{\eta=0}$
ATLAS	7TeV,	p_t>0.5GeV, $n_{ch} \geq 6$	$\left.\frac{dn_{ch}}{d\eta}\right\rvert_{\eta=0}$
ATLAS	7TeV,	p_t>0.5GeV, $n_{ch} \geq 1$	$\left.\frac{dn_{ch}}{d\eta}\right\rvert_{\eta=0}$

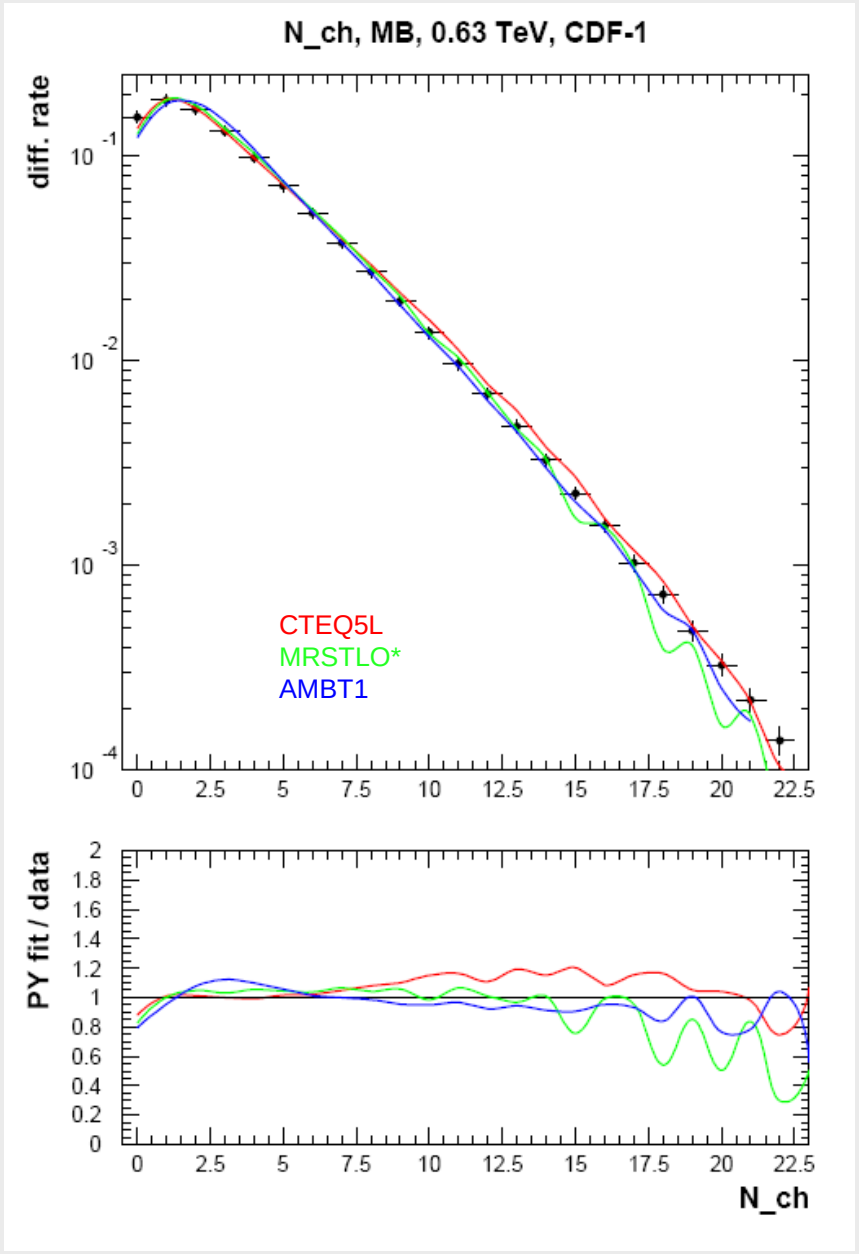
List of tuned parameters

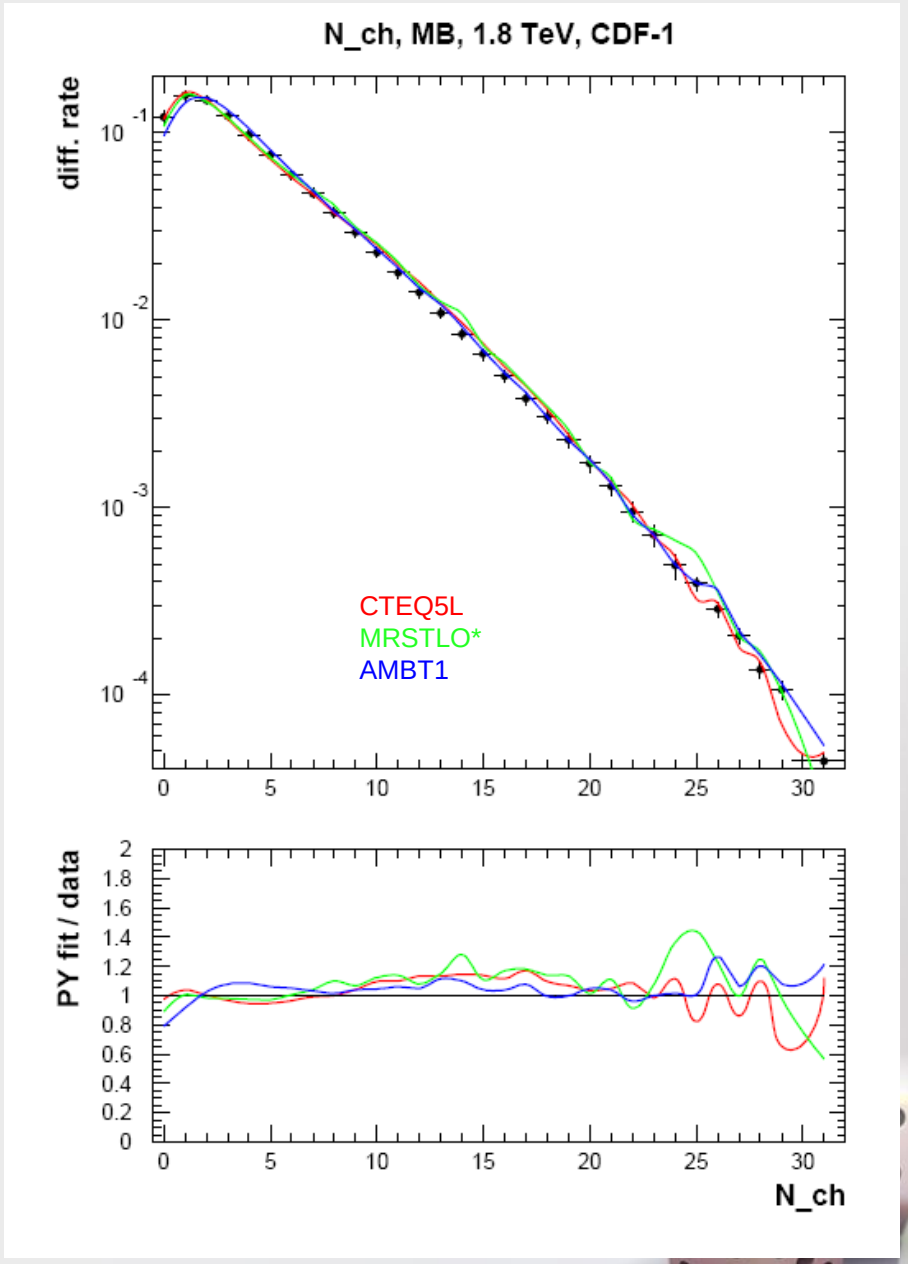
Parameters	Pythia Default	Tune CTEQ5 CDF	Tune CTEQ5 LHC	Tune CTEQ5 Both	Tune MRSTLO* CDF	Tune MRSTLO* LHC	Tune MRSTLO* Both	Description
PARP(82)	2.00	1.78	1.69	1.76	2.01	1.92	1.99	P⊥0 at reference Ecm
PARP(83)	1.8	2.09	2.54	2.24	2.18	2.37	2.27	matter distribution
PARP(78)	0.03	0.49	0.52	0.51	0.39	0.47	0.41	colour reconnection in FS
PARP(90)	0.16	0.22	0.23	0.24	0.21	0.22	0.22	p⊥0 evolution with Ecm
PARP(77)	0	1.64	1.64	1.64	1.64	1.64	1.64	Suppression of CR for fast moving strings

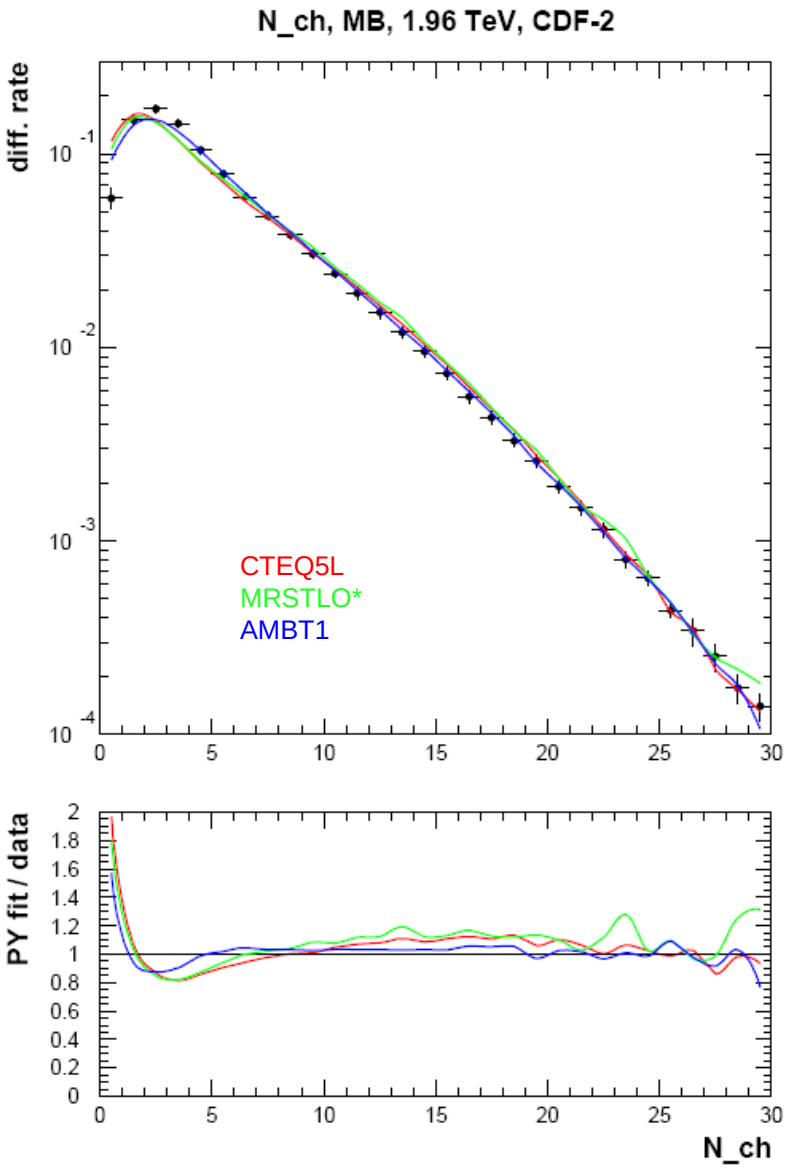
	Tune CTEQ5 CDF	Tune CTEQ5 LHC	Tune CTEQ5 Both	Tune MRSTLO* CDF	Tune MRSTLO* LHC	Tune MRSTLO* Both	AMBT1 CDF	AMBT1 LHC	AMBT1 Both
Chi^2/dof	7.16	2.00	5.23	14.10	3.42	11.38	7.01	1.58	6.01

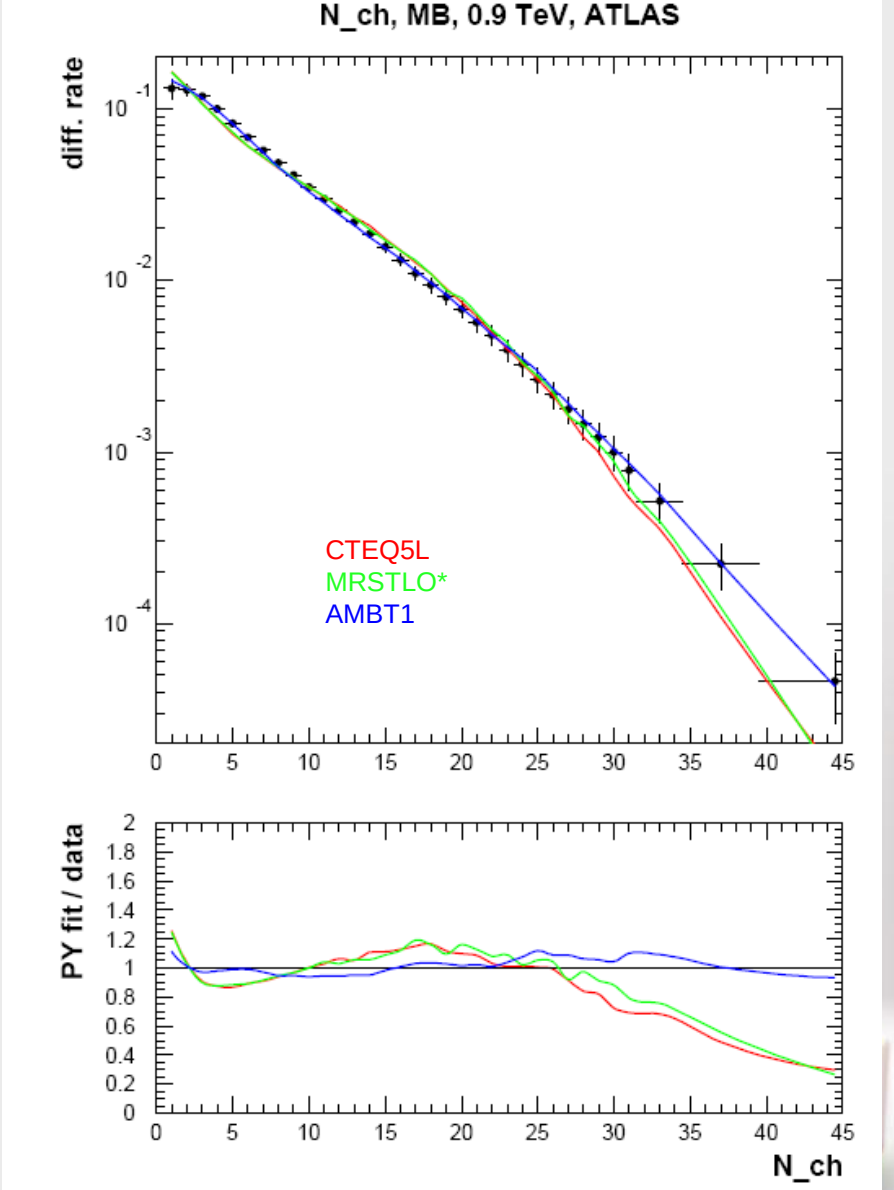
Central Charged Densities

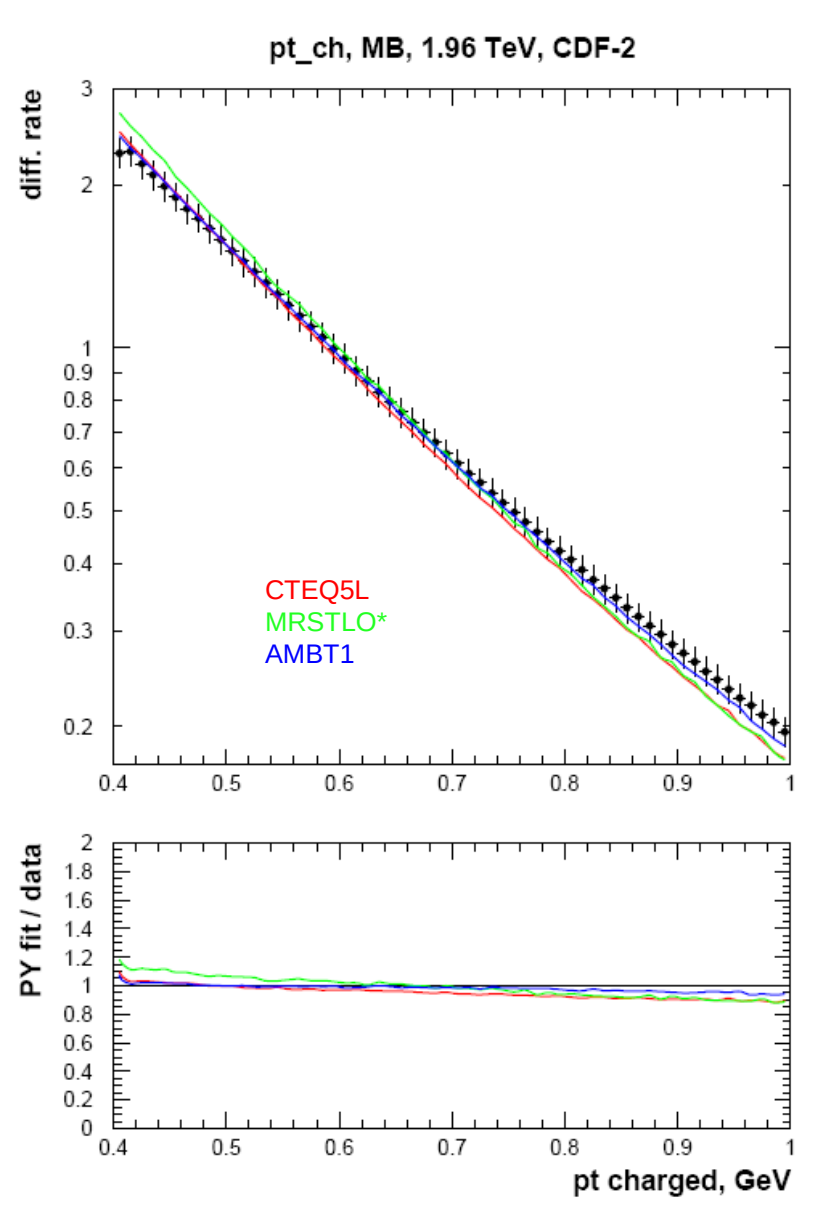
Analysis				Data	MC Overall fit	
ALICE	0.9 TeV,	no p_t cut,	$n_{ch} \geq 1$	3.81 ± 0.07	3.56	3.60
ALICE	7 TeV,	no p_t cut,	$n_{ch} \geq 1$	6.01 ± 0.15	5.18	4.81
ATLAS	0.9 TeV,	$p_t > 0.5$GeV,	$n_{ch} \geq 6$	2.38 ± 0.08	2.43	2.45
ATLAS	7TeV,	$p_t > 0.5$GeV,	$n_{ch} \geq 6$	3.64 ± 0.12	3.69	3.40
ATLAS	7TeV,	$p_t > 0.5$GeV,	$n_{ch} \geq 1$	2.42± 0.08	2.26	2.34

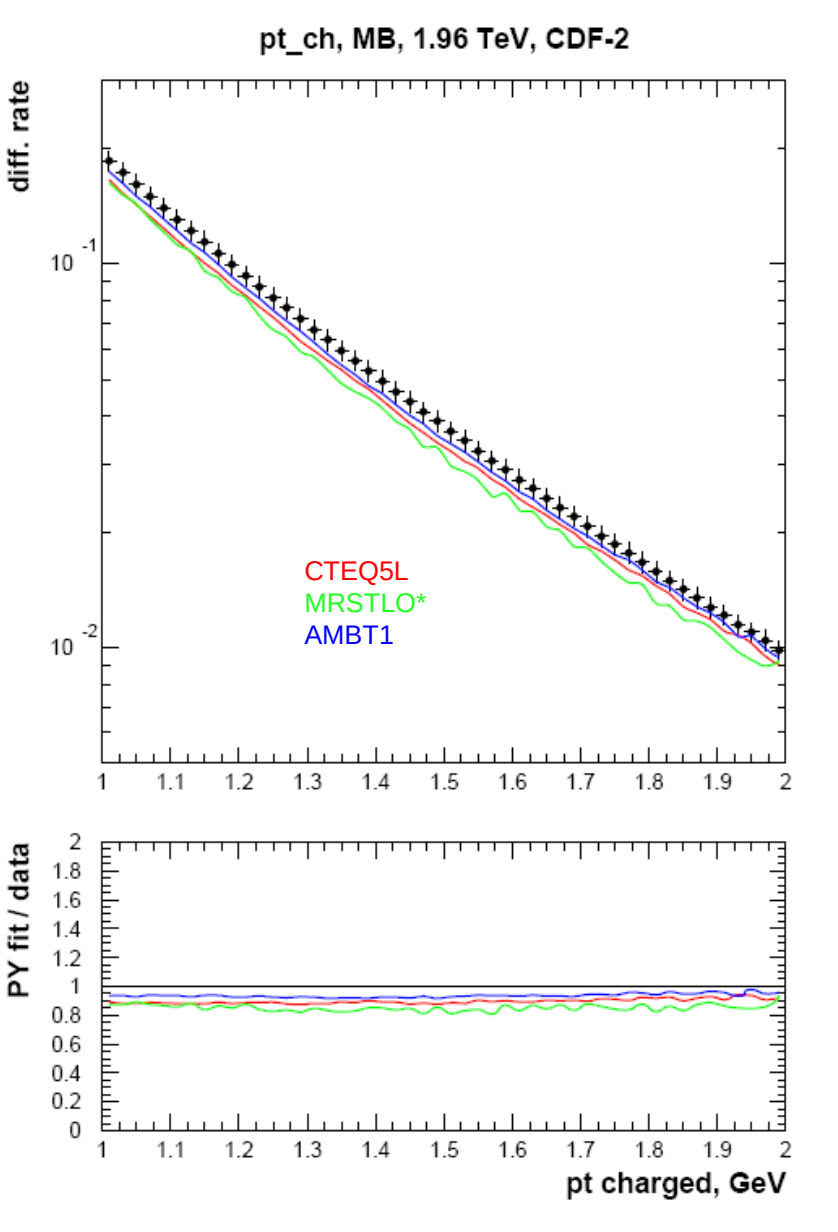

N_ch, MB, 0.63 TeV, CDF-1
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
N_ch

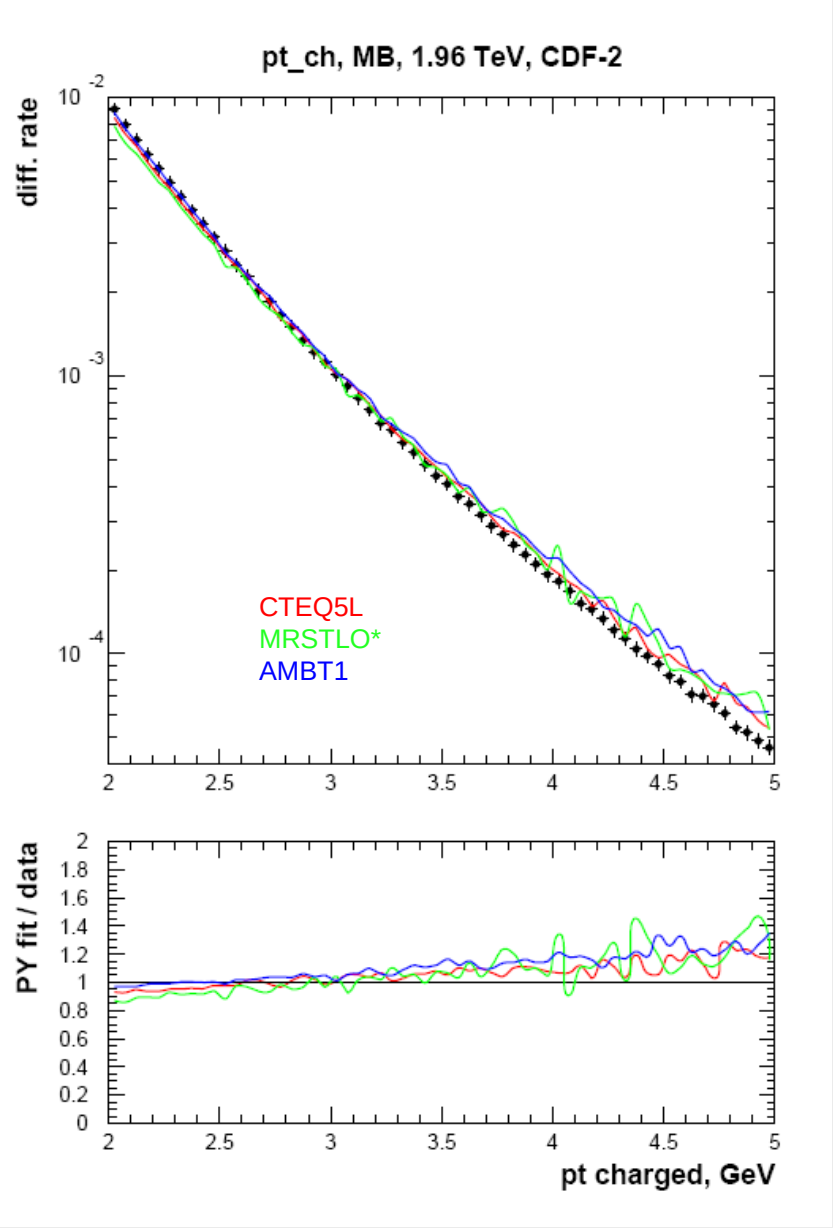

N_ch, MB, 1.8 TeV, CDF-1
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
N_ch

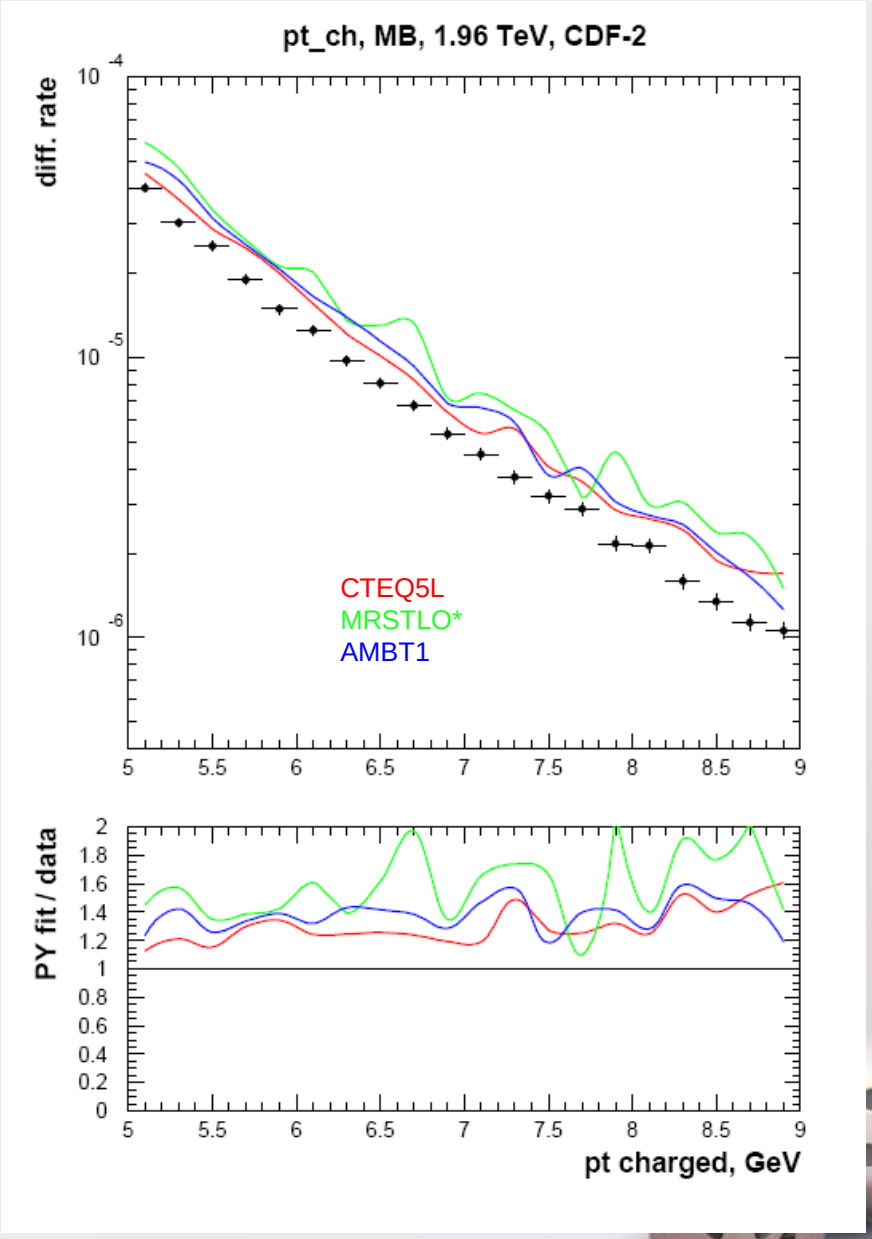

N_ch, MB, 1.96 TeV, CDF-2
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
N_ch

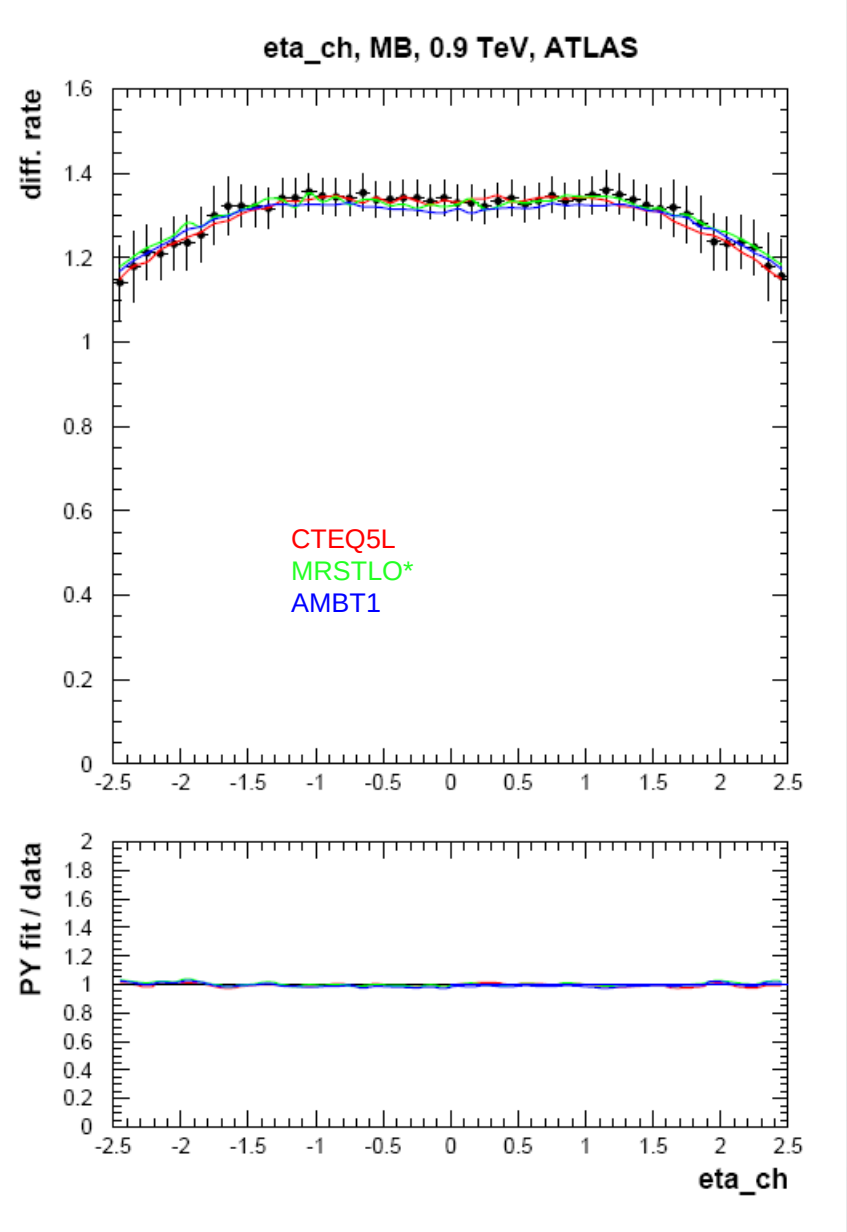

N_ch, MB, 0.9 TeV, ATLAS
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
N_ch

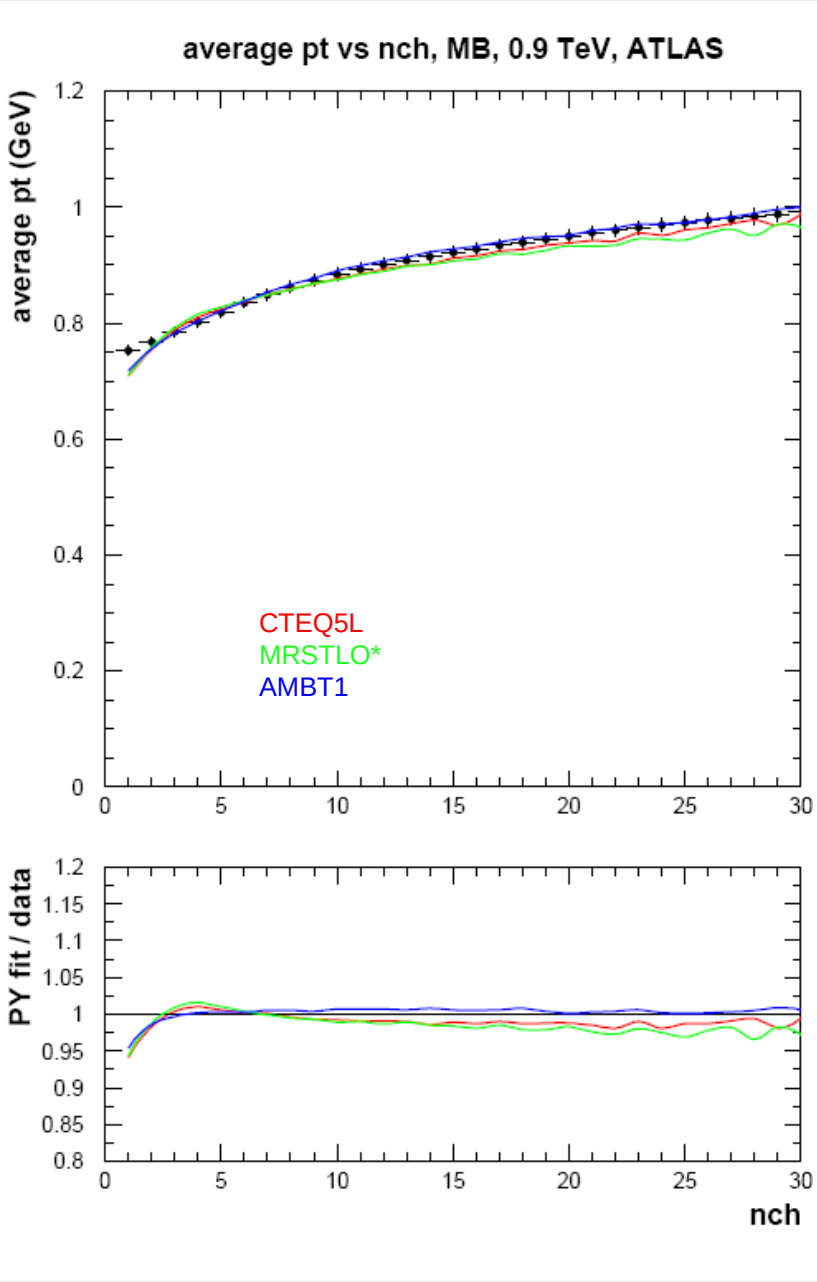

pt_ch, MB, 1.96 TeV, CDF-2
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV

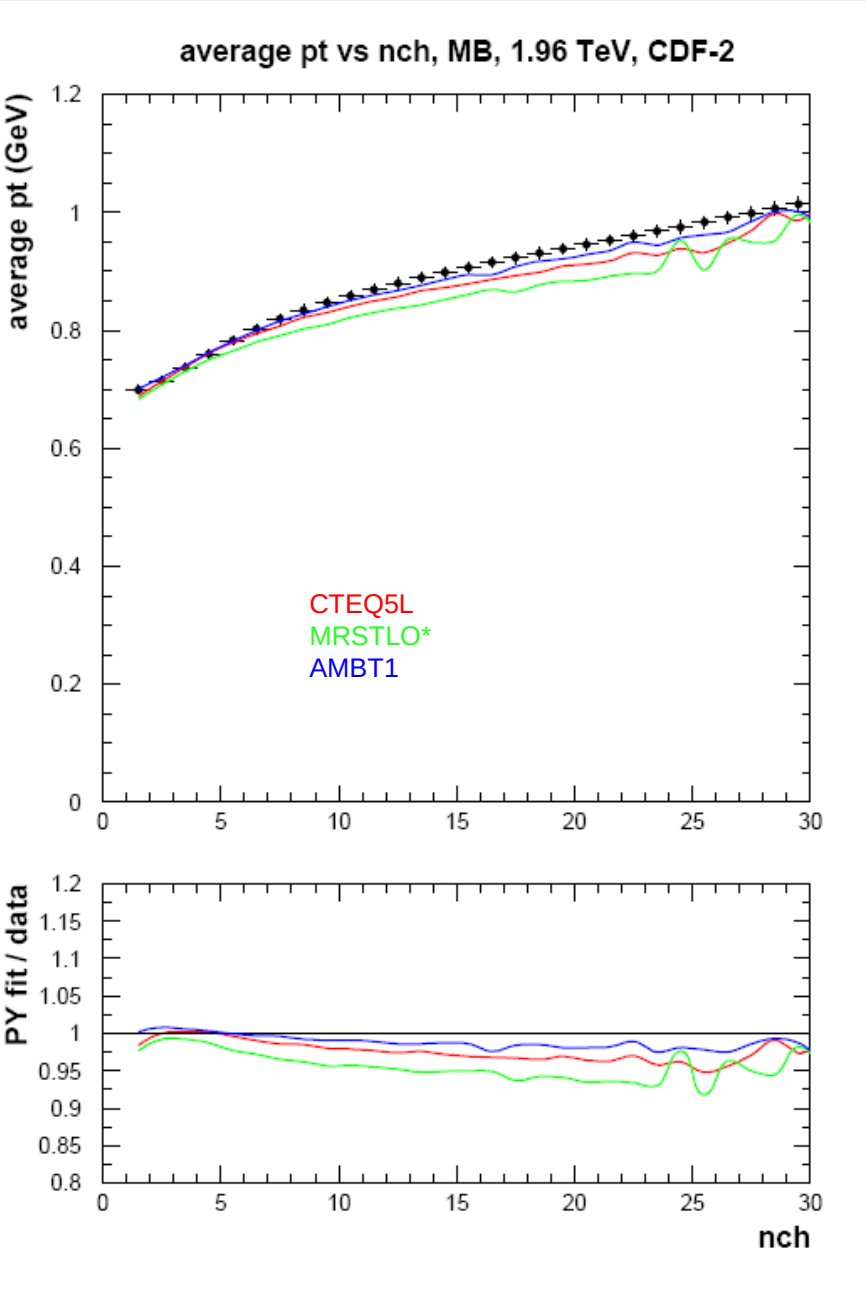

pt_ch, MB, 1.96 TeV, CDF-2
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV

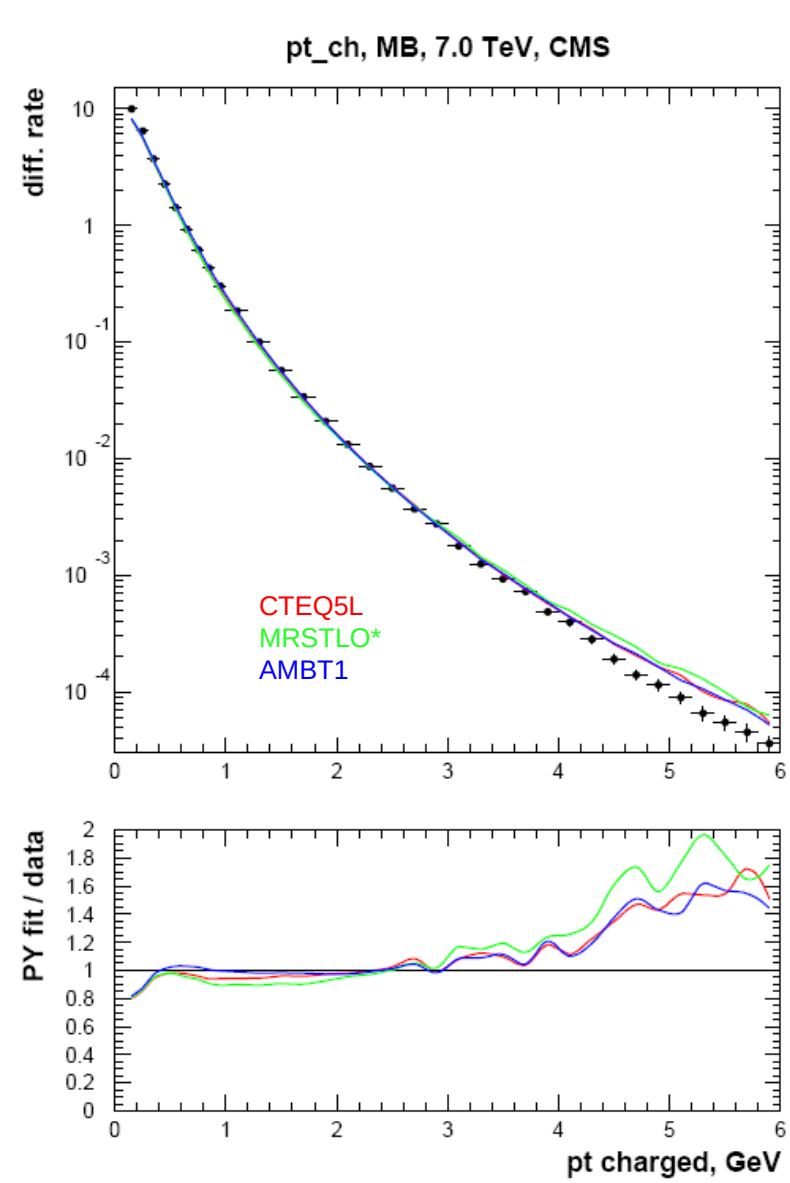

pt_ch, MB, 1.96 TeV, CDF-2
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV

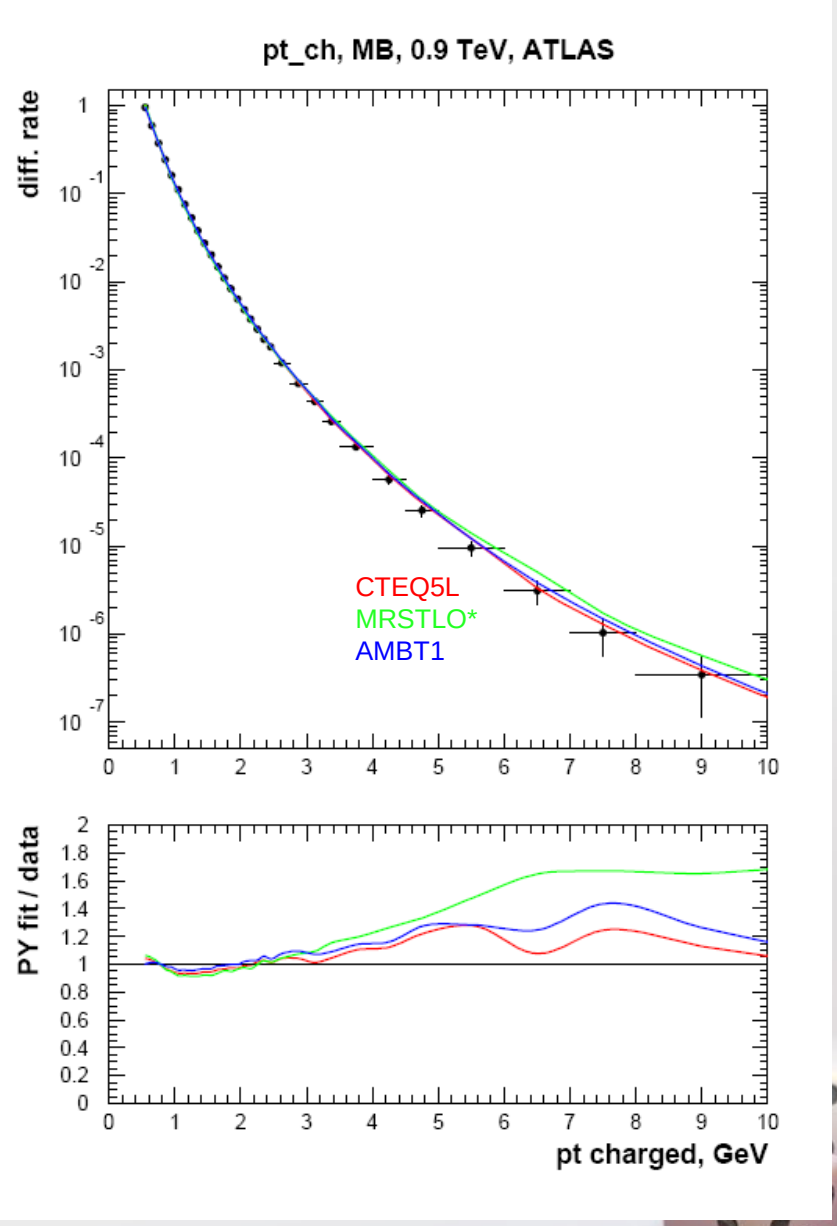

pt_ch, MB, 1.96 TeV, CDF-2
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV


eta_ch, MB, 0.9 TeV, ATLAS
diff. rate
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
CTEQ5L
MRSTLO*
AMBT1
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
PY fit / data
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
eta_ch


average pt vs nch, MB, 0.9 TeV, ATLAS
average pt (GeV)
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
nch


average pt vs nch, MB, 1.96 TeV, CDF-2
average pt (GeV)
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
nch


pt_ch, MB, 7.0 TeV, CMS
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV


pt_ch, MB, 0.9 TeV, ATLAS
diff. rate
CTEQ5L
MRSTLO*
AMBT1
PY fit / data
pt charged, GeV

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- Most important parameters of the PYTHIA MPI model are tuned and compared to the AMBT1
- Tuning results for LHC and CDF II data are inconsistent
- Minimum Bias collisions are mixture of hard and soft processes, therefore, very difficult to simulate

Thanks